PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

De-Superheater for Steam or other Superheated Vapour.

I, ALFRED KENNETH PORTER, of 466 Russell Court, Woburn Place, London, W.C.1, a British Subject, do hereby declare the invention for which I pray that a patent may be granted to me and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to apparatus for de-superheating steam or other superheated vapour (including superheated vapour mixtures) during flow, by pumping or injecting cooling water, or whatever other liquid corresponds to the vapour, into the stream of superheated vapour.

The object of the invention is to provide simple and efficient apparatus for this purpose capable of substantially completely de-superheating a vapour supply without producing an excess of condensate in the de-superheated vapour.

With this object in view, an apparatus according to the present invention, a separating chamber provided for separating condensate from the de-superheated vapour is arranged to discharge the condensate into a receiver communicating with the suction side of the pump or injector and thus to return the condensate to the main vapour stream, the apparatus being designed so that the entry of condensate into the receiver automatically checks the supply of cooling liquid to the pump or injector and thereby regulates the operation of the apparatus. Advantageously it does this by generating flash vapour in the receiver and thereby creating a back pressure at a supply opening provided for the entry of cooling liquid into the apparatus.

The communication between the separating chamber and the receiver may be controlled in a very simple manner by making use of the difference between the rate at which vapour will pass through an orifice from a high pressure region to a low pressure region in the vapour phase, and the rate at which vapour will flash from hot condensate passed through the same orifice in the liquid phase. For this purpose, the separating chamber is made to communicate with the receiver through a restricted orifice of such size that the rate of flow of vapour therethrough, in the absence of condensate, is insufficient to interfere with the supply of cooling liquid, whereas the evolution of vapour from the condensate, when condensate passes through the orifice in the liquid phase, raises the pressure in the receiver sufficiently to check the cooling liquid supply. A self regulating system of extremely simple construction is thus provided.

In the preferred form of the invention, an injector is provided for sucking liquid from a low pressure supply and injecting it into the superheated vapour stream, thereby avoiding the need for a pump for raising the pressure of the liquid, the injector being effective over a working range of rates of flow of steam or vapour through the apparatus. Owing to the fact that the liquid thus injected evaporates in contact with the superheated steam or vapour as it absorbs the superheat thereof, there is no rejection of heat by the apparatus.

The invention and its subsidiary features will be fully understood from the following more detailed description of one example of an apparatus embodying the invention, reference being made to the accompanying drawing in which the only Figure is a sectional elevation of the apparatus.

The apparatus comprises the following parts:—An injector A; an upper vessel B which serves as a separating chamber; a lower vessel C constituting a receiver separated from the chamber B by a diaphragm D; an orifice plate E controlling the flow of fluid through a hole in the diaphragm D surrounded by a weir F covered by a screen

G for protecting the orifice plate; a pipe J connecting the receiver C to the suction chamber L of the injector; a supply pipe K for cooling liquid; a non-return valve H controlling an inlet opening through which the pipe K supplies cooling liquid to the receiver C. The part marked M is the nozzle part of the injector. P is a further orifice plate which controls the communication between the receiver C and the suction side of the injector A.

The injector A is of the convergent and divergent nozzle type in common use and is designed in accordance with well-known principles to give the least possible pressure drop consistent with inducing a partial vacuum in the suction chamber L under ordinary working conditions. The body A forming the divergent part of the injector, the outer wall of the chamber L and the end flanges, may conveniently be cast, forged or fabricated in steel, iron, bronze or other suitable material. The nozzle M may conveniently be a separate piece fitting into a recess in the inlet flange. This part M may conveniently be a casting or turning in iron, steel, bronze or other material. Alternatively, it could be cast or fabricated as an integral part of the body A.

The upper vessel B is similar in design to the simple type of steam drier in common use; conveniently it is a cylinder closed at the top by a blind flange or integral end. The bottom is open, and conveniently may be flanged to take the diaphragm D. The vessel has two ports with external branches, facings or the like, one forming the outlet N for the saturated vapour and the other being attached by a flange, screwed joint, welding or the like means to the outlet end of the injector A. However, the injector A and upper vessel B could be one piece. The inlet to the vessel B could be tangential, the outlet port being in the top cover in alignment with the vertical axis of the vessel. Alternatively, the two ports conveniently may be arranged side by side with their axes vertical. With the latter arrangement, and with the arrangement shown in the drawing, the vessel is fitted with so-called mid-feather, dividing the vessel from the top to within a convenient distance from the diaphragm D. The vessel B may be cast, forged, or fabricated in steel, iron, bronze or other material. The mid-feather may be integral with the vessel, or it may be a separate plate fitting into grooves formed in the shell, or otherwise attached to the shell of the vessel.

The diaphragm D is simply a plate separating the upper vessel B from the lower vessel C. Conveniently it may be machined in iron, steel, bronze or other material. It may be bolted or welded to the vessels with gaskets where required. A hole, as small as may easily be drilled, is drilled right through the thickness of the plate at some convenient point. This point should preferably, but not necessarily, be in the outlet half of the vessel.

The lower vessel or receiver C forms a shallow cup at the bottom of the apparatus and may be of just sufficient depth to easily accommodate the non-return valve H. This vessel has two ports, either screwed or arranged with facings, branches or the like. One port is fitted with the non-return valve H and pipe K. The other port is fitted with the pipe J. The vessel C may be cast, forged or fabricated in steel, iron, bronze or other material.

The orifice plate E is a thin piece of stainless steel, copper or the like. The edge is cut to fit snugly inside the weir F, which locates it in position. At a point co-axial with the hole in the diaphragm D there is a small, sharp-edged hole in the orifice plate. This hole may be only a few hundredths of an inch in diameter, whereas the hole through the orifice plate P may be a quarter of an inch or more in diameter.

The weir F is a shallow ring either rectangular or circular, with flat faces top and bottom. It is fixed to the upper face of the diaphragm D by bolts, welding or other means.

The screen G is a fine mesh perforated plate in stainless steel, copper or the like. Its function is to prevent the orifice in the plate E from being choked with scale or the like. It does not otherwise enter into the functioning of the apparatus.

The non-return valve H may be of the hinged lid, poppet, or free ball type. Instead of being fitted inside the vessel C as shown it could be accommodated in the pipe K at some distance from the vessel C or it could be incorporated in a sleeve fitted into the port in the lower vessel C in such a manner that the sleeve and valve may be withdrawn without disturbing the joint between the diaphragm D and the body of the vessel C.

In the following description of the functioning of the apparatus the terms "steam" and "water" will be used but it is to be understood that the description is equally applicable in principle to other vapours and liquids.

In use the apparatus is fitted into a horizontal length of a steam main, the axis of the injector A being in a substantially horizontal position whereas the axes of the vessels B and C are substantially vertical.

The superheated steam enters through the convergent nozzle M of the injector A and the saturated steam leaves at the outlet port N.

The steam passes through the throat of the injector at such high velocity that it induces a partial vacuum in the space L, pipe J and vessel C. Owing to the pressure difference thus created between the upper and the lower vessels, steam passes through the

orifice E. The quantity of steam passing is however so restricted by the smallness and the sharp edge of the orifice and by the critical velocity that the injector is able to suck it into the main stream and still reduce the pressure in the vessel C to less than atmospheric pressure. This reduced pressure induces the water to rise through pipe K, lift the non-return valve H and flow into the vessel C. Steam entering the vessel C is now condensed by the water, thus maintaining the low pressure. The incoming water with the condensed steam is sucked out of the vessel C by the injector and entrained by the steam passing through the divergent nozzle into the upper vessel B. The quantity of water so entrained conveniently may be arranged to de-superheat and wet saturate the steam. In the upper vessel B, the excess water and condensate is thrown out of the steam and falls to the bottom of the vessel. The steam thus leaves the outlet port N as dry, or slightly wet, saturated steam. The water collecting at the bottom of the vessel B flows over the weir F and through the orifice E into the lower vessel C.

In any practicable application of the apparatus, the weight of water flowing through the orifice E in unit time, when the weir F is full, is approximately twenty to forty times the weight of steam flowing through the orifice in unit time when the weir is empty. This water flowing down through the orifice is very hot due to intimate contact with high pressure superheated steam. On reaching the lower vessel therefore about one tenth to one quarter of this water will flash off into steam at a little less than atmospheric pressure. The volume of the flash steam is over four times the volume of steam that reaches the lower vessel when the weir F is empty of water. This ratio is determined from the before mentioned twenty/forty weight ratio and the high superheat of the wiredrawn steam.

The large difference between the rate at which steam enters the lower vessel as steam, and the rate at which it is generated by flashing from water that has passed through the orifice E in the liquid phase enables the apparatus to be designed so that the steam flow through the orifice does not interfere with the flow of cooling water into the vessel C, whereas the flash steam generated when liquid flows through the orifice increases the pressure in the vessel C sufficiently to shut the valve H and stop the flow of cooling water. In the construction shown, this effect of the flash steam is mainly due to the orifice plate P which restricts the inlet to the suction side of the injector sufficiently to ensure that the flash steam increases the pressure in the vessel C as required. The orifice plate P has the advantage that its choking effect can be easily calculated. Moreover, it can be readily adjusted by changing the orifice plate. Should the pressure in the lower vessel fail to rise above atmospheric, the water will fill the lower vessel and rise up through the hole in the diaphragm to meet the water in the upper vessel. When this meeting occurs the water in the lower vessel will be at the same pressure as the steam due to static hydraulic pressure. This pressure will close the non-return valve.

With the non-return valve H held closed by flash-steam pressure, all the water in the lower vessel will be injected into the upper vessel. When no more water is drawn in by the injector, the superheated steam passes into the upper vessel still superheated. But the superheated steam, in passing over the surface of the water lying in the upper vessel, loses its superheat and becomes dry saturated. The heat lost by the superheated steam evaporates the water lying in the upper vessel. When sufficient water has been evaporated so that water ceases to flow over the weir, steam again flows through the orifice E. This wire-drawn steam is immediately aspirated by the injector A which again reduces the pressure in the lower vessel C to less than atmospheric. This reduced pressure induces the cooling water to rise through pipe K, lift the non-return valve H, and flow into the vessel C. The cycle of operation then begins again and is repeated indefinitely.

The self-regulating action of the apparatus is such as to maintain a supply of saturated steam at N provided that the supply of superheated steam is maintained and the steam load is kept within working limits for which the apparatus is designed. For the purpose of supplying steam with a predetermined reduced degree of superheat, a de-superheating apparatus according to the invention may be used to supply saturated steam to a mixing device in which the saturated steam is mixed with superheated steam, the rate of supply of superheated steam being regulated by a proportioning valve controlled thermostatically in dependence upon the temperature of the steam delivered by the mixing device.

What I claim is :—

1. Apparatus employing a pump or injector for de-superheating steam or other vapour during flow by pumping or injecting cooling water, or whatever other liquid corresponds to the vapour, into the superheated vapour stream, wherein a separating chamber provided for separating condensate from the de-superheated vapour is arranged to discharge the condensate into a receiver communicating with the suction side of the pump or injector and thus to return the condensate to the main vapour stream, the apparatus being designed so that the entry of condensate into the receiver automatically

checks the supply of cooling liquid to the pump or injector and thereby regulates the operation of the apparatus.

2. Apparatus as claimed in Claim 1. wherein the condensate checks the supply of cooling liquid by generating flash vapour in the receiver and thereby creating a back pressure at a supply opening provided for the entry of cooling liquid into the apparatus.

3. Apparatus as claimed in Claim 1 or 2, wherein the separating chamber communicates with the receiver through a restricted orifice of such size that the rate of flow of vapour therethrough, in the absence of condensate, is insufficient to interfere with the supply of cooling liquid, whereas the evolution of vapour from condensate, when condensate passes through the orifice in the liquid phase, raises the pressure in the receiver sufficiently to check the cooling liquid supply.

4. Apparatus as claimed in Claim 2 or 3 wherein the supply opening through which the cooling liquid enters the apparatus is controlled by a non-return valve.

5. Apparatus as claimed in Claim 2, 3 or 4 wherein the communication between the receiver and the suction side of the pump or injector is controlled by a restricted orifice.

6. Apparatus for de-superheating steam or other vapour substantially as herein described with reference to the accompanying drawing.

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PROVISIONAL SPECIFICATION.

De-Superheater for Steam or other Superheated Vapour.

I, ALFRED KENNETH PORTER, of 466 Russell Court, Woburn Place, London, W.C.1, British, do hereby declare this invention to be described in the following statement:—

The Apparatus is a means of removing the superheat from steam or other gas, which is at a pressure substantially above atmospheric, by the assimilation of water, or other liquid, from a source at approximately atmospheric pressure. This is accomplished without using a pump or any other external means of raising the pressure of the liquid. Further, as the superheat is absorbed by the liquid, which is evaporated in contact with the steam or gas, there is no rejection of heat by the Apparatus.

The Apparatus, which is illustrated in the accompanying drawing, comprises essentially the following parts:—(A) The Injector. (B) The Upper Vessel. (C) The Lower Vessel. (D) The Diaphragm. (E) The Orifice Plate. (F) The Weir. (G) The Screen. (H) The Non-Return Valve. (J) The Pipe connecting (A) to (C). (K) The Pipe connection to the Cooling Liquid Source.

The Injector (A) is of the convergent and divergent nozzle type in common use. The throat of the nozzle communicates with an annular space (L) surrounding the convergent part by means of a radial or inclined passage. The Injector (A) and (M) conveniently is proportioned to give the least possible pressure drop consistent with inducing a partial vacuum in the annular space (L). The body of the Injector forming the divergent part, the outer case of the annular space and the end flanges may conveniently be cast, forged or fabricated in steel, iron, bronze or the like. The convergent part of the nozzle (M) may conveniently be a separate piece fitting into a recess in the inlet flange. This part (M) may conveniently be a casting or turning in iron, steel, bronze or the like. Alternatively the convergent part (M) could be cast or fabricated as an integral part of the body of the Injector (A).

The Upper Vessel (B) is similar in design to the simple type of steam dryer in common use. Conveniently it is a cylinder closed at the top by a blind flange or integral end. The bottom, open, end conveniently may be flanged to take the Diaphragm Plate (D). The vessel has two ports with external branches, facings or the like. One port (N) is the outlet for the saturated vapour. The other port (P) is the inlet, and is attached by a flange, screwed joint, welding or the like means to the divergent end of the Injector (A). Alternatively the Injector (A) and the Upper Vessel (B) may be one piece. The inlet port could be tangential to the vessel, with the outlet port in the top cover on the vessel axis. Alternatively, the two ports conveniently may be arranged with their vertical axial planes coincident with the axial plane of the vessel. With the latter arrangement the vessel is fitted with a so-called mid-feather dividing the vessel from the top to within a convenient distance from the Diaphragm (D). The Upper Vessel (B) conveniently may be cast, forged, or fabricated in steel, iron, bronze or the like. The mid-feather may be either integral with the vessel or, alternatively, a separate plate fitting into grooves formed in the shell, or otherwise attached to the shell of the vessel.

The Diaphragm (D) is a simple plate dividing the Upper Vessel from the Lower Vessel. Conveniently it may be machined in iron, steel, bronze or the like. Con-

veniently it may be bolted or welded between the Upper Vessel and the Lower Vessel with gaskets where required. A hole, as small as may easily be drilled. is drilled right through the thickness of the plate at some convenient point. This point should preferably, but not necessarily, be in the outlet half of the Apparatus.

The Lower Vessel (C) forms a shallow cup at the bottom of the Apparatus. Conveniently it may be of just sufficient depth to easily accommodate the Non-Return Valve (H). The vessel has two ports, either screwed or arranged with facings, branches or the like. One port is fitted with the Non-Return Valve (H) and the Pipe (K). The other port is fitted with the Pipe (J). Conveniently the vessel is flanged at the top and open end to take the Diaphragm (D). The Lower Vessel (C) conveniently may be cast, forged or fabricated in steel, iron, bronze or the like.

The Orifice Plate (E) is a fairly thin piece of stainless steel, copper, or the like. The edge is cut to fit snugly inside the Weir (F), which locates it in position. At a point co-axial with the hole in the Diaphragm there is a small, sharp edged hole in the Orifice Plate. Conveniently, this hole in the Orifice Plate is only a few hundredths of an inch in diameter.

The Weir (F) is a shallow ring either rectangular or circular, with flat faces top and bottom. It is fixed to the upper face of the Diaphragm by bolts, welding or the like means. Conveniently it may be a fabricated piece in iron, steel, bronze or the like.

The Screen (G) is a fine mesh perforated plate in stainless steel, copper or the like. It is fitted to the top of the Weir (F). The function of the Screen is to prevent the Orifice from becoming choked with scale or the like. It does not otherwise enter into the functioning of the Apparatus.

The Non-Return Valve (H) could conveniently be the hinged lid, poppet, or free ball type or the like. Conveniently it could be a proprietary article or the like. Alternatively, the Non-Return Valve (H) instead of being on the inside of the Lower Vessel (C) as shown on the drawing, conveniently may be on the outside inserted into the length of the Pipe (K). Alternatively, the Non-Return Valve (H) conveniently may be incorporated in a sleeve fitted into the port in the Lower Vessel (C) in such a manner that the sleeve and valve may be withdrawn from the Apparatus without disturbing the Diaphragm joint.

The Pipe (K) connects the Non-Return Valve (H) to the source of water or other liquid. The Pipe (K) conveniently may be standard steel, copper or the like tube, with standard fittings.

The Pipe (J) connects the Lower Vessel (C) with the annular space surrounding the convergent part of the Injector (A), conveniently it may be standard tube similar to Pipe (K).

In the following description of the functioning of the Apparatus, the term steam will be used for the gas or vapour, and the term water for the liquid. Nevertheless, the Apparatus conveniently may be applied to other gasses and use other liquids.

In use the Apparatus conveniently is fitted into a horizontal length of a steam main; the axis of the Injector (A) conveniently lying in the horizontal plane with the axes of the Upper and Lower Vessels (B) and (C) lying in the vertical plane.

The superheated steam enters the convergent nozzle (M) of the Injector (A) in the direction shown by the arrow. The saturated steam leaves the Apparatus at the outlet port (N).

The steam passes through the throat of the Injector at a high velocity. The high velocity steam issuing from the convergent nozzle entrains the surrounding air and thus induces a partial vacuum in the annular space and via the Pipe (J) aspirates air from the Lower Vessel (C). Owing to the pressure difference between the Upper and the Lower Vessels steam passes through the Orifice (E). The quantity of steam passing is restricted by the smallness and the sharp edge of the Orifice and by the critical velocity. The performance of the Injector may conveniently be arranged to aspirate a large proportion of the steam passing through the Orifice, reducing the remainder to less than atmospheric pressure. This reduced pressure induces the water to rise through Pipe (K), lift the Non-Return Valve (H) and flow into the Lower Vessel (C). Steam entering the Lower Vessel (C) is now condensed by the water, thus maintaining the low pressure. The incoming water with the condensed steam is sucked out of the Lower Vessel by the Injector and entrained by the steam passing via the divergent nozzle into the Upper Vessel (B). The quantity of water entrained conveniently may be arranged to de-superheat and wet saturate the steam. In the Upper Vessel (B) the excess water and condensate is thrown out of the steam and falls to the bottom of the vessel. The steam leaves the outlet port (N) as dry, or slightly wet, saturated steam. The water collecting at the bottom of the Vessel (B) flows over the Weir (F) and through the Orifice (E) into the Lower Vessel (C).

In any practicable application of the Apparatus, the weight of water flowing through the Orifice in unit time, when the Weir is full, is approximately twenty to thirty times the weight of steam flowing through the Orifice in unit time when the Weir is empty. This water flowing down

through the Orifice is very hot due to intimate contact with high pressure superheated steam. On reaching the Lower Vessel about one sixth of this water will flash off into steam at about atmospheric pressure. The volume of the flash steam is about three times the volume of the steam reaching the Lower Vessel when the Weir is empty of water. This ratio is determined from the before mentioned twenty/thirty weight ratio and the high superheat of the wire-drawn steam.

The large difference between the rate at which steam enters the Lower Vessel as steam, and the rate at which it is generated from flashing water, permits the convenient design of the Injector. Conveniently the Injector may be designed to induce a low pressure in the Lower Vessel when steam is entering through the Orifice. It also may conveniently be designed to allow the pressure to increase to above atmospheric when hot water flashing to steam enters through the Orifice. Convenentily the capacity of the Non-Return Valve is less than the capacity of the Injector.

When the pressure in the Lower Vessel rises above atmospheric the Non-Return Valve closes, preventing further ingress of water into the Apparatus. Should the pressure in the Lower Vessel fail to rise above atmospheric, the water will fill the Lower Vessel and rise up through the hole in the Diaphragm to meet the water in the Upper Vessel. When this meeting occurs the water in the Lower Vessel will be at the same pressure as the steam due to static hydraulic pressure. This pressure will close the Non-Return Valve.

With the Non-Return Valve held closed by flash-steam pressure, all the water in the Lower Vessel will be injected into the Upper Vessel. When no more water is drawn in by the Injector, the superheated steam passes into the Upper Vessel still superheated. But the superheated steam, in passing over the surface of the water lying in the Upper Vessel, loses its superheat and becomes dry saturated. The heat lost by the superheated steam evaporates the water lying in the Upper Vessel. When sufficient water has been evaporated so that water ceases to flow over the Weir, steam flows through the Orifice into the Lower Vessel. This wire-drawn steam is aspirated by the Injector, thus reducing the pressure in the Lower Vessel to less than atmospheric. This reduced pressure induces the cooling water to rise through Pipe (K), lift the Non-Return Valve, and flow into the Lower Vessel. The cycle of operation is again repeated as described in the foregoing.

A. K. PORTER.

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772,058 PROVISIONAL SPECIFICATION

1 SHEET

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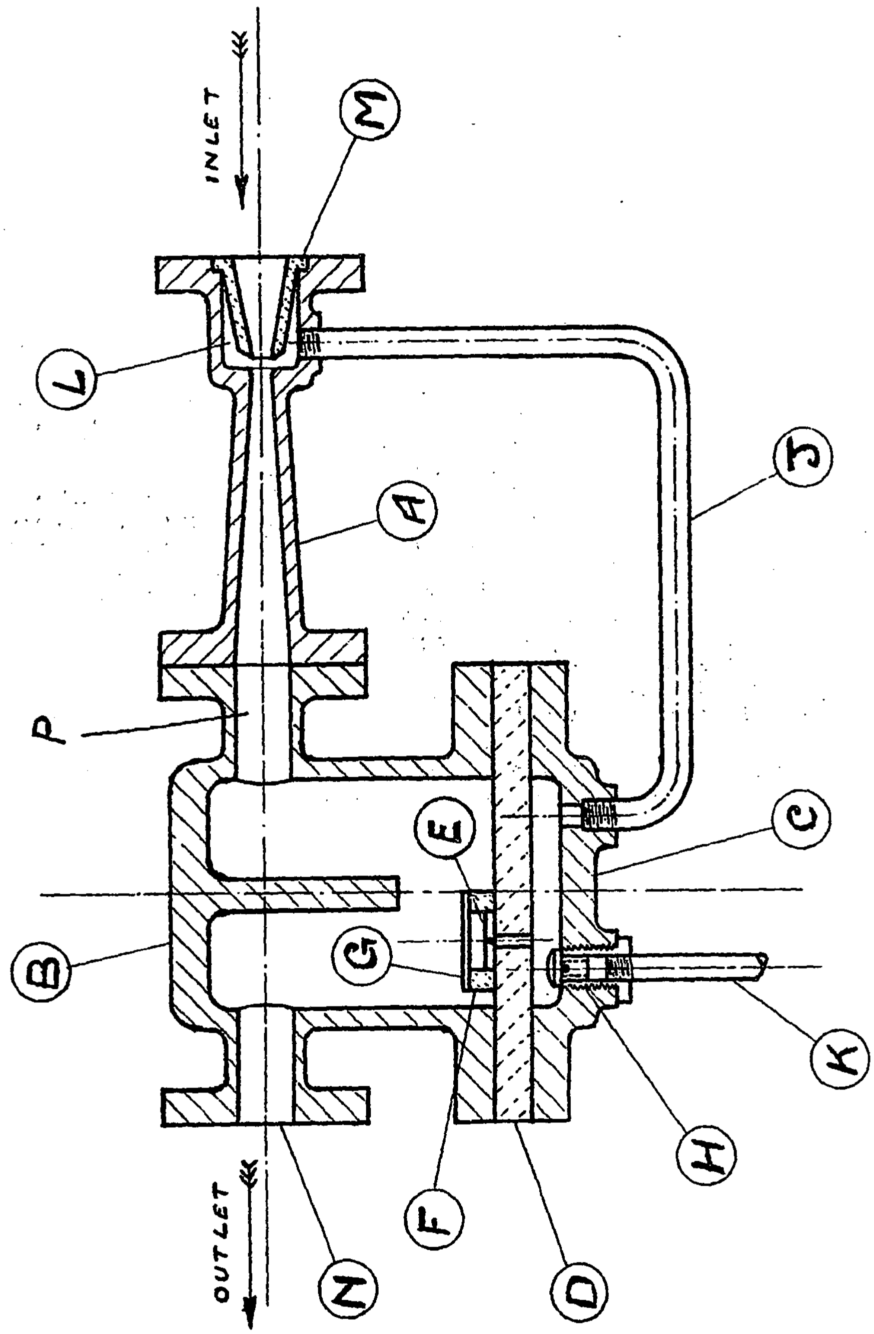

772,058 COMPLETE SPECIFICATION
1 SHEET

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